

Outline for the guide

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- C. Economics (to be completed)
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FERTILIZER MATERIALS AND CALCULATIONS GUIDE

Background

A fertilizer is any amendment applied to soil or plants that provides essential plant nutrients. Most fertilizers are highly soluble salts (i.e. potassium chloride, KCl). That dissociate when brought in contact with water.

Fertilizers are classified according to the percent by weight of plant nutrient(s) they contain. The analysis or grade refers to the minimum amounts of N, P_2O_5 and K_2O in a fertilizer. Grades for P and K are expressed as oxides, rather than on an elemental basis. Fertilizer recommendations are also given on an oxide basis, for example lbs P_2O_5 /acre or lbs K_2O /acre. Oxide forms are used only to indicate amounts of P and K in fertilizer Phosphorus and K in fertilizer are not actually present as P_2O_5 or K_2O and plants do not take up P_2O_5 or K_2O .

Elemental name	Elemental symbol	Oxide name	Oxide symbol	Plants use
Nitrogen	N	Nitrate	NO_3^-	NO_3^-
Phosphorus	P	Phosphate	P_2O_5	$H_2PO_4^-$
Potassium	K	Potash	K_2O	K^+

Why is phosphorus express as P_2O_5 and potassium expressed as K_2O ?

Historically, chemists used a gravimetric (weighing) method to determine the phosphorus and potassium content of fertilizers in the form of phosphorus pentoxide (P_2O_5) and potassium oxide (K_2O). By convention, the amounts (or analysis/grade) of phosphorus and potassium in fertilizers are still expressed in this oxide form. The Association of American Plant Food Control officials have developed a uniform fertilizer label which says that available P_2O_5 and soluble K_2O must be guaranteed by the manufacturer and so the guaranteed analysis must still be expressed in the oxide form. Nitrogen content has always been expressed as simply N.

According to conventional fertilizer standards, a 100 pound bag of 10-10-10 contains 10% or 10 pounds of nitrogen, 10% or 10 pounds of P_2O_5 and 10% or 10 pounds of K_2O . Since P_2O_5 is really only 44% actual elemental phosphorus and K_2O is only 83% actual elemental potassium, a 100 pound bag of 10-10-10 contains 10% or 10 pounds of nitrogen, 4.4% or 4.4 pounds of elemental phosphorus and 8.3% or 8.3 pounds of elemental potassium.

Perhaps the reluctance of the fertilizer industry to convert to expressing the nutrients in the elemental forms is due to the perception that less fertilizer is being purchased for the same amount of money. A 100 pound bag of 10-10-10 containing N, P_2O_5 and K_2O would be equivalent to a 100 pound bag of 10-4.4-8.3 containing N, P and K.

To convert between the elemental and oxide forms of P and K use the following relationships:

Elemental P * 2.29 = P_2O_5 or

Oxide form of P, P_2O_5 * 0.44 = elemental P

Elemental K * 1.2 = K_2O or

Oxide form of K, K_2O * 0.83 = elemental K

Once the fertilizer is added to the soil, the oxide forms, P_2O_5 and K_2O , are no longer used when referring to these two nutrients. The amount of these nutrients analyzed in the soil is expressed as the pounds per acre of elemental P and K.

Complete fertilizer, contains all of the three primary nutrients, N-P-K (i.e. 6-24-24)

Mixed fertilizer, contains more than one of the three primary nutrients, N-P-K and/or sometimes a secondary nutrient like sulfur (S) or boron (B) (i.e. 18-46-0)

Single nutrient carrier, contains only one of the three primary nutrients N, P or K (i.e. 46-0-0).

100 lb of 0-14-42-2B contains:

0 lb N, 14 lb P_2O_5 , 42 lb K_2O , and 2 lb B

Why is a fertilizer that contains a single nutrient such as N in a product like urea (46-0-0) not 100% N?

Now for a little chemistry!

The chemical formula for urea (46-0-0) is $CO(NH_2)_2$

ATOMIC WEIGHTS

Carbon (C) = 12 (* 1 = 12)

Oxygen (O) = $16 (* 1 = 16)$

Nitrogen (N) = $14 (* 2 = 28)$

Hydrogen (H) = $1 (* 4 = 4)$

Total atomic weight of urea = 60

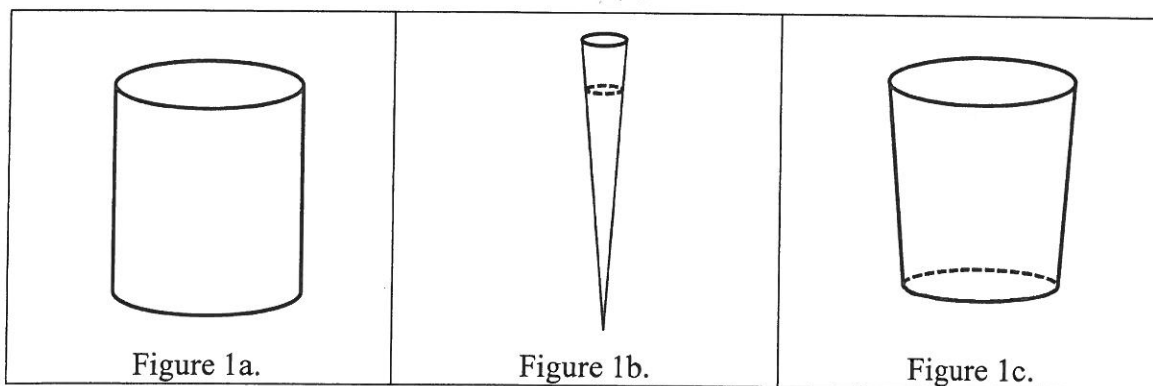
Amount of N by weight (mass) in urea is determined by dividing the atomic weight of N in urea by the total atomic weight or urea or $28/60 = 0.46666$. Converting the decimal fraction to a percent ($0.46 * 100$) we arrive at urea contains 46% N or 46 pounds of N per 100 pounds of urea.

Four steps in making fertilizer calculations.

1) Determine the area.

Our example will be targeted toward greenhouse pots although there are numerous ways to incorporate these calculations into a curriculum, for example, fertilizing a lawn or farm field of specific geometry.

There are a couple options for doing the calculations. Option one is based on the assumption that the pot is a right circular cylinder (Figure 1a). Option two is based on the assumption that the pot is the frustum of a right circular cone (Figure 1b,1c). Option two is the more realistic, albeit, a more complicated scenario.

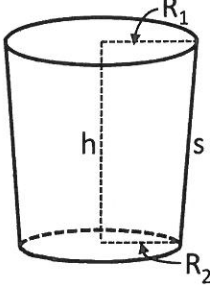


The total area of the right circular cylinder, Figure 1a, is $A = \pi R^2 s$, where R is the radius of the top or bottom of the cylinder since they are the same dimension. Remember that the radius is defined as one-half the diameter. The s term represents the slant height, or in the case of a right circular cylinder the height.

The total area of the frustum of a right circular cylinder, Figure 1c, is $A = \pi[R_1^2 + R_2^2 + (R_1 + R_2)s]$, where R_1 is the radius of the top and R_2 is the radius of the bottom of the cylinder. The s term represents the slant height, which in the case of the frustum of a right circular cylinder is $s = \sqrt{(R_1 - R_2)^2 + h^2}$, where h is the distance between the upper and lower bases.

An example:

What is the area, in *square feet*, of a three gallon pot with the following dimensions?

	$R_1 = 4.5$ inches $R_2 = 3.875$ inches $h = 7.5$ inches $s = 7.75$ inches
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Do your calculation here. Watch your units

$s = \sqrt{(R_1 - R_2)^2 + h^2}$	$s = \sqrt{(X - X)^2 + Y^2}$
$A = \pi[R_1^2 + R_2^2 + (R_1 + R_2)s]$	$A = \pi[X^2 + X^2 + (X + X)s]$

In order to determine the amount of fertilizer needed for your greenhouse projects we may want to know the acre equivalent area of your pot. [1 acre equals 43,560 square feet. (43,560 ft²)].

The area of the pot is equal to what fraction of 1 acre?
Do your calculation here.

Tomato and Pepper fertilizer guidelines:

A soil test is the most accurate guide to fertilizer requirements.

Nitrogen: 100-150 lb N/acre.

Sidedress with 35-50 lb N/acre after the first flowers are set.

Phosphate: 100-150 (P₂O₅) lb/acre

Potash: 100-200 (K₂O) lb/acre depending on soil test.

pH: Add lime if below 6.0

Practice Problems for Fertilizer Analysis

Quick review: Nutrients are present in a fertilizer; thus, the amount of nutrient in a fertilizer will depend on the fraction of the material that is the nutrient. Also, P and K are often expressed as P_2O_5 and K_2O , respectively. For example, $P \times 2.29 = P_2O_5$; or $P_2O_5/2.29 = P$ (see problem solutions below). In converting P_2O_5 to P, one may either divide by 2.29 or multiply by 0.44 to get the same answer.

- $\% \text{ nutrient} = (\text{pounds of nutrient/pounds of fertilizer}) \times 100$
- $\text{pounds of nutrient} = (\% \text{ nutrient}/100) \times \text{pounds of fertilizer}$
- $\text{pounds of fertilizer} = \text{pounds of nutrient}/(\% \text{ nutrient}/100)$

1. What is the fertilizer analysis of pure ammonium nitrate NH_4NO_3 ? (atomic weights: N=14, H=1, O=16)

One must determine the percentage of N in this molecule. To do this, divide the weight of N in the molecule by the molecular weight of the compound.

The molecular weight is:

$$\begin{aligned} &N + H + O \\ &2(14) + 4(1) + 3(16) = 80 \end{aligned}$$

Therefore, in 80 g of NH_4NO_3 , one has 28 g of N

2. If 120 lbs of NH_4NO_3 were applied per acre, how many lbs of N are applied?

We must first know the percentage N in the fertilizer. If we are not given this, we must calculate it as above. For this problem, we will assume the fertilizer is 35-0-0.

3. If 160 lbs of starter (6-10-8) were applied per acre, how many lbs of N, P_2O_5 , and K_2O are applied?

Unless otherwise given, we must assume the fertilizer is labeled on the oxide basis (standard). Therefore, this fertilizer is N - P_2O_5 - K_2O , and the numbers are percentages.

4. If a soil test report calls for 80 lbs of K_2O per acre, how many lbs of muriate of potash (KCl) must be applied to meet this requirement?

This is a two-step problem. We must first determine (or know) the analysis of muriate of potash. From lecture, we learned it is a 0-0-60 fertilizer (oxide basis). Next we must calculate the quantity of this fertilizer to give us 80 lbs of K_2O .

5. Some fertilizers are "dual labeled" in that they have both elemental and oxide form on the label. Also, most scientific literature reports all nutrient analyses on the elemental basis. If a bag of fertilizer were labeled as containing 40% K_2O , what is the analysis when expressed as %K?

This question is similar to problem #1. We must either know the conversion factor or (better yet) be able to calculate it. We are really asking the percentage of K in K_2O . at wts: K=39, O=16

The molecular weight is:

6. In a similar problem, assume the bag is labeled as 20% P. Calculate the percentage P_2O_5 in the bag.

Here we are converting from the elemental to the oxide basis, but the principles are the same. at wts: P=31, O=16

The molecular weight is:

$$2(31) + 5(16) = 142$$

7. If a 50-lb bag of urea (45-0-0) costs \$8.00, what is the cost per lb of N?

In a 50-lb bag of urea, we have 22.5 lbs of N (50 lbs fert. X 0.45 = 22.5)

Therefore, the cost per lb is:

8. If P_2O_5 is worth 38¢ per lb and a ton of pure K_2HPO_4 sells for \$484, how much are you paying per lb of K_2O ? Hint: must determine the pounds of P_2O_5 and K_2O (convert both to oxide basis) per 2000 pounds of K_2HPO_4 .

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This problem requires several logical steps. First, we must determine the percentage of K and P in K_2HPO_4 . Second, we must convert the K to K_2O and the P to P_2O_5 . Third, we must determine how many pounds of K_2O and P_2O_5 are present in one ton of K_2HPO_4 . Fourth, we must determine the value of the P_2O_5 . Fifth, we must subtract the value of the P_2O_5 from \$484. Lastly, we must divide the difference by the pounds of K_2O present to determine costs per lb of K_2O .

First:

Second:

Third:

Fourth:

Fifth:

Last:

9. Assume that you wish to make a bulk blend and add 300 lbs of 0-46-0 and 200 lbs of 0-0-60. What is the analysis of this blend (assume everything is on the oxide basis)?

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This is a relatively simple and very practical problem (most cooperatives do this many times in the fall and spring in loading trucks to send to the field). Remember that 0-46-0 is an analysis; i.e., the fertilizer contains 46% P_2O_5 . If you dilute this with a material that contains no P_2O_5 , the analysis will decrease. In 300 lbs of 0-46-0, we have 138 lbs P_2O_5 . In 200 lbs of 0-0-60, we have 120 lbs K_2O . When we mix the two materials together to give us 500 lbs total weight, we have 138 lbs P_2O_5 and 120 lbs K_2O . The decimal equivalent of P_2O_5 is $138/500 = 0.276$ or 27.6%.

10. A soil test report calls for 80 lbs P_2O_5 and 95 lbs K_2O per acre. You have 20 acres that need fertilized. If the source of P_2O_5 is 0-46-0 and the source of K_2O is 0-0-60, how many pounds of each fertilizer must you blend together to fill the truck going to the field? What will be the final analysis of the blended fertilizer?

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Deficiency Symptoms

Nutrient

a. The dominant symptom is chlorotic foliage.

b. Entire leaf blades are chlorotic.

c. Only the lower leaves are chlorotic followed by necrosis and leaf drop.

Nitrogen

a. Leaf chlorosis is not the dominant symptom.

b. Symptoms appear at base of plant.

c. At first, all leaves are dark green followed by stunted growth. Purple pigment often develops in leaves, particularly older leaves.

Phosphorus

cc. Margins of older leaves become chlorotic and then burn, or small chlorotic spots progressing to necrosis appear scattered on old leaf blades.

Potassium